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FINAL REPORT
ON THE
OPERA[illegible] EVALUATION
[illegible]
RECONNAIS[illegible]
[illegible]
([illegible] UNCLA[illegible]D)

PROJECT NO. APG/[illegible]

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ABSTRACT

Project No. APG/TAS/519-A was primarily a functional evaluation of the MA-3 SHORAN Reconnaissance Navigational System conducted by the Air Force Armament Center and actively monitored by the Air Proving Ground Command to determine the operational suitability of the system as installed in the RB-57A aircraft for obtaining SHORAN coordinates of targets, and for SHORAN-controlled aerial photography.

The MA-3 SHORAN Reconnaissance Navigational System, as installed in the RB-57A aircraft, is not operationally suitable to fulfill its tactical requirement. It was determined during the conduct of this test that the Recorder Group of the MA-3 system is not compatible with the AN/APN-84 SHORAN Radio Set, and that the MA-3 system is not compatible with the operational altitude capabilities of the RB-57A aircraft, due to unreliable operation of the AN/APN-84 SHORAN Radio Set. The latter deficiency was encountered in two previous operational suitability tests conducted by this Command. (Reference final report on the Operational Suitability Test of the S-4 SHORAN Bombing System, Project No. APG/SAS/71-A-1, and final report on the Operational Suitability Test of the B-57B Aircraft, Project No. APG/TAS/119-A.) However, test results indicate that modifications to the AN/APN-84 SHORAN Radio Set and the SHORAN Recorder Group, as recommended in this report and its associated report, "Air Force Armament Center Engineering Evaluation of the SHORAN Recorder Group," if incorporated, will result in a system suitable for tactical SHORAN reconnaissance.

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HEADQUARTERS
AIR PROVING GROUND COMMAND
Eglin Air Force Base, Florida

Office of the
Commander

27 April 1956

SUBJECT: (UNCLASSIFIED) Final Report on Operational Evaluation of the MA-3 SHORAN Reconnaissance Navigational System in the RB-57A, Project No. APG/TAS/519-A

TO: All Recipients

The subject report is approved.

ROBERT W. BURNS
Major General, USAF
Commander

[redacted]

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1. INTRODUCTION:

a. Background:

(1) Accuracy of ground controlled bombing systems such as SHORAN, AN/MSQ-1, and guided missile employment depends on exact knowledge of target location. The primary objective of SHORAN reconnaissance is to obtain the position of the target or objective point in relation to SHORAN ground stations. SHORAN reconnaissance is essentially the reverse application of the SHORAN bombing problem. In bombing, predetermined SHORAN coordinates are incorporated into the bombing system and the aircraft is flown to a geographical location. In reconnaissance the aircraft is navigated by SHORAN or some other method to the target area, so that exact SHORAN readings (coordinates) of photographed targets can be obtained for later use in bombing.

(2) Project No. APG/TAS/519-A was established in accordance with AFR 80-14. The Air Proving Ground Command (APGC) in conjunction with the Air Force Armament Center (AFAC) conducted the joint functional-operational evaluation of the MA-3 SHORAN Reconnaissance Navigational System in the RB-57A aircraft. Functional operation of, and data pertaining to, this system may be found in the "Air Force Armament Center Engineering Evaluation of the SHORAN Recorder Group," AFAC Project 6251 B_1.

b. Purpose of Test Item: Since reliable geodetic data near tactical targets are not always available, some form of pre-strike reconnaissance must be accomplished over many targets. The MA-3 SHORAN Reconnaissance Navigational System was designed to fulfill existing Tactical Air Command requirements for obtaining pre-strike reconnaissance data.

c. Description of Test Item: The MA-3 system is comprised of the SHORAN Recorder Group and the basic precision SHORAN Airborne Equipment, Radio Set AN/APN-84. The SHORAN Recorder Group was designed and manufactured by Vectron Incorporated, Waltham, Massachusetts. The Recorder Group, which utilizes a double pulsing transmission, replaces the need for an operator to align and track received SHORAN pulses with their corresponding reference pulses, since the Recorder Group performs this function continuously and automatically. Photographs of SHORAN distance dials are synchronized with terrain photographs of a gyro-stabilized terrain camera so that the position of targets which appear in the terrain camera photographs may be accurately matched with photographs of the SHORAN distance dials. In addition to aircraft positional data, aircraft heading, pressure altitude, and free air temperature are included on each exposure of the SHORAN Recording Camera film. The SHORAN Recording Camera, which is mounted in a port in the front of the control indicator, is a modified O-20 type. (Reference Figure 1.) It is especially designed for minimum size and weight requirements, utilizing 35mm type film. For vertical terrain photographs, a cartographic type T-11 camera was used during daylight operation. An A-28 gyro-stabilized camera mount was used in the tactical-configured RB-57A test-bed aircraft. The following indicators were suspended from the pilot's lower right radio panel (reference Figure 2) and above the operator's MA-3 controls (reference Figure 3).

(1) <u>Range Indicator ID-509(XA)/APN-84 (Rate and Drift Indicator)</u> shows the SHORAN mileage from both the rate and drift stations.

(2) <u>Range Indicator ID-510(XA)/APN-84 (Sum Indicator)</u> presents the sum of the values of the distance to the rate station and the distance to the drift station.

(3) <u>Range Indicator ID-511(XA)/APN-84 (One-Half Difference Indicator)</u> presents one-half the difference of the aircraft's distance to the drift station from the aircraft's distance to the rate station.

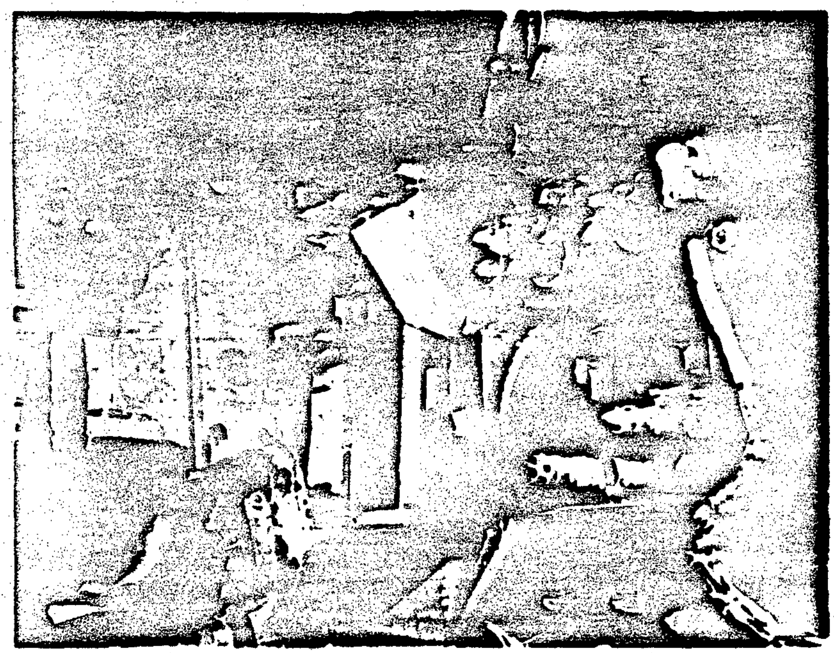

Figure 1

Showing MA-3 Installation at the Operator's Position in the RB-57A Test Aircraft. (Arrow Showing O-20 Camera Installed in the Port of SHORAN Recorder Group.)

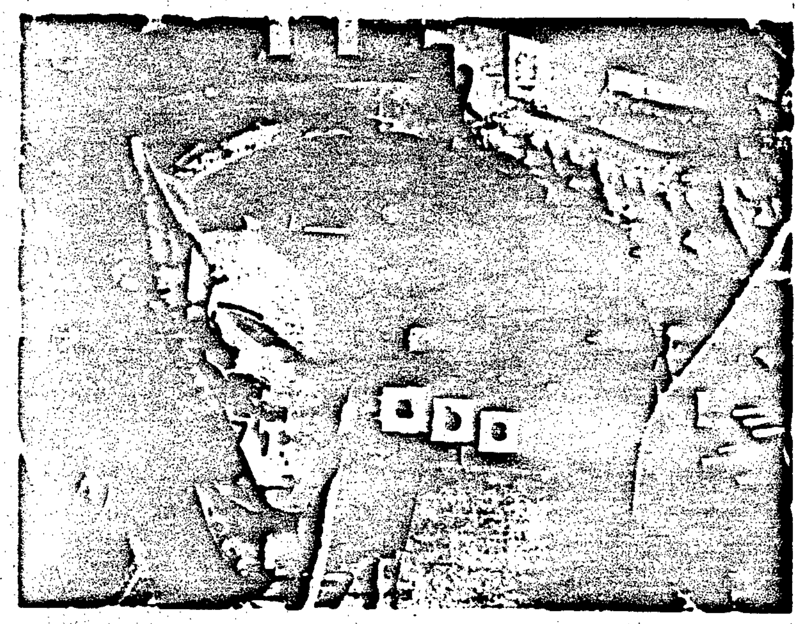

Figure 2

Showing Pilot's Three Indicators.

a) Range Indicator ID-509(XA)/APN-84
(Rate and Drift Indicator)
b) Range Indicator ID-510(XA)/APN-84
(Sum Indicator)
c) Range Indicator ID-511(XA)/APN-84
(One-Half Difference Indicator)

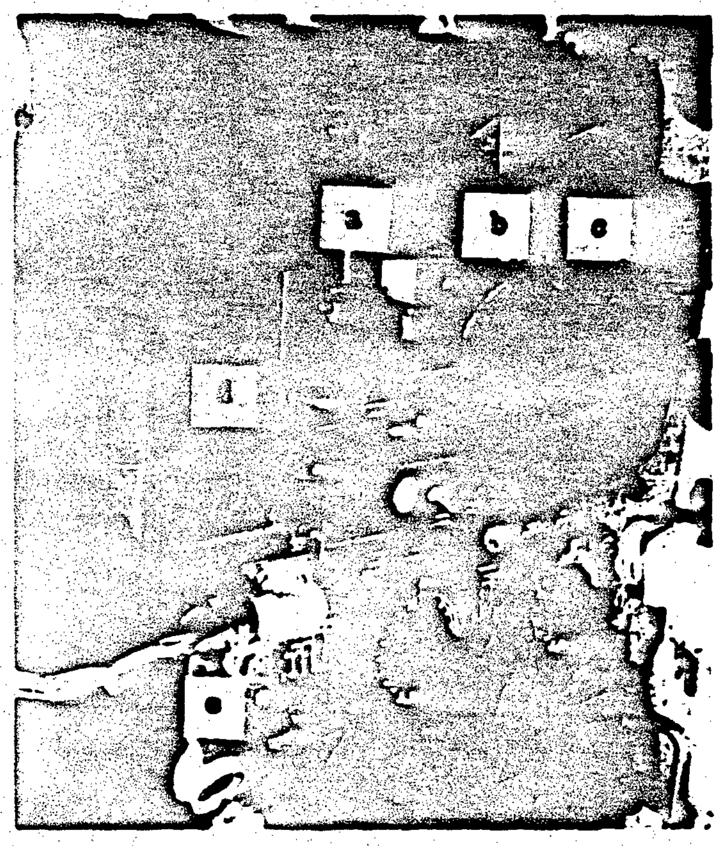

Figure 3

a) ID-509(XA)/APN-84 Rate and Drift Indicator
b) ID-511(XA)/APN-84 One-Half Difference Indicator
c) ID-510(XA)/APN-84 Sum Indicator
d) AN/APN-84 Indicator (IP-186)
e) SHORAN Recorder Group

2. OBJECT OF TEST:

To determine the operational suitability of the MA-3 SHORAN Reconnaissance Navigational System for determining SHORAN coordinates of targets, and for SHORAN-controlled aerial photography. Principal considerations were as follows:

a. Accuracy of the MA-3 system.

b. Operational capabilities and limitations.

c. Procedures for running a flight line with the MA-3 SHORAN system.

d. Equipment reliability and maintenance requirements.

e. Preflight requirements and computations necessary for proper MA-3 SHORAN operation.

f. AFSC's and training required for personnel to operate and maintain the MA-3 system.

g. Adequacy of existing operating and maintenance publications and ground support equipment.

3. CONCLUSIONS:

It is concluded that:

a. The MA-3 SHORAN Reconnaissance Navigational System, as installed in the RB-57A aircraft, is not operationally suitable in its present configuration. This unsuitability is primarily attributed to:

(1) The AN/APN-84 T-342 Transmitter Oscillator and its associated power supply, which are not compatible with the SHORAN Recorder Group because of overloading caused by the double pulse transmission requirement of the MA-3 system.

(2) Intermittent failure of the T-342 Transmitter Oscillator (located in the AN/APN-84 portion of the MA-3 system) when operating in an unpressurized compartment at altitudes of approximately 40,000 feet and above. This malfunction was encountered

on two previous tests conducted by this Command (reference final report on the Operational Suitability Test of the S-4 SHORAN Bombing System, Project No. APG/SAS/71-A-1, and final report on the Operational Suitability Test of the B-57B Aircraft, Project No. APG/TAS/119-A), involving the AN/APN-84 Radio Set, and since previously recommended modifications pertaining to this equipment have not been accomplished, the equipment is not capable of meeting "high altitude" tactical SHORAN Reconnaissance requirements.

b. Test results indicate that modifications as recommended in this report and its associated report, "Air Force Armament Center Engineering Evaluation of the SHORAN Recorder Group," if incorporated into the MA-3 system, will provide the RB-57A with a suitable SHORAN Reconnaissance System for tactical employment.

c. Pilots, observers, and maintenance personnel with previous experience with AN/APN-84 SHORAN operation will have no difficulty becoming qualified in the MA-3 system upon completion of the recommended orientation. (Reference paragraph 5f.)

4. RECOMMENDATIONS:

a. The present circuitry of the AN/APN-84 T-342 Transmitter Oscillator and its associated power supply be redesigned to prevent overloading caused by the double pulsing feature of the MA-3 system, and the mechanical commutator in the T-342 Transmitter Oscillator be replaced with an Electronic (Tube) switching system to provide the MA-3 system with a reliable "high altitude" SHORAN Reconnaissance capability.

b. It is recommended that the modifications listed in Appendix A be incorporated into the MA-3 SHORAN Reconnaissance System to eliminate minor deficiencies encountered during this test.

c. It is further recommended that the automatic feature of the MA-3 SHORAN Reconnaissance System be incorporated into the rate circuits of SHORAN bombing systems (such as the S-4 SHORAN Bombing System) to allow the operator additional time for monitoring bombing controls and for improved accuracy.

5. **TEST RESULTS AND DISCUSSION:**

a. **Accuracy of the MA-3 System:**

(1) **Test Environment and Procedures:**

(a) The 20 test missions flown during the conduct of this test were limited to day photo runs at 20,000 and 40,000 feet altitude at true airspeeds up to 480 knots. Three of these missions were for operator familiarization. All photo runs were made at an average distance of 112 statute miles from the SHORAN ground stations. Two successive frames of film from each usable photo run were evaluated by AFAC photogrammetrists.

(b) The AFAC Photogrammetric Range (Eglin AF Base Range No. 70) was utilized to evaluate all positional data recorded on test missions. To determine the aircraft's true ground position, aerial photographs of this range were corrected for aircraft pitch and roll utilizing a MANN Comperator and an ERA (Electronic Research Associates) 1103 high speed electronic digital computer.

(c) All missions were flown during VFR conditions. Portions of some missions were flown while experiencing mild, clear air turbulence, but this turbulence had no apparent effect on MA-3 operation.

(d) There was no electronic countermeasure phase required or performed against the MA-3 system during this test.

(e) Four night missions were programmed during this test but were cancelled because the test aircraft was returned to the Tactical Air Command. (These missions were to utilize a K-37 type camera and M-120 photo-flash bombs.) This system was ground checked for synchronization by AFAC personnel and was found to operate satisfactorily.

(2) Test Results and Analysis:

(a) From the photographs of the Photogrammetric Range taken by the T-11 Vertical Camera, and the SHORAN positional data recorded by the O-20 Camera, three separate ground positions were obtained:

1. The true ground position (Nadir Point) of the aircraft, as determined by the MANN Comparator, from photographs taken by the T-11 Vertical Camera.

2. The apparent ground position of the aircraft as determined by the exact center (Principal Point) of the Vertical Camera photo.

3. The SHORAN ground position of the aircraft as determined by the SHORAN mileage readings as recorded by the O-20 Camera in the SHORAN Recorder.

(b) Theoretically, the Nadir Point, Principal Point, and SHORAN coordinates should resolve accurately to identify one common position or identical point. However, sources of error in the MA-3 system and allied camera equipment result in inaccuracies. The following sources of error in the MA-3 system and its allied equipment were considered when data were evaluated:

1. Instability of the T-11 Vertical Camera, which results in a difference between true ground position and apparent ground position.

2. Improper synchronization between the T-11 Vertical Camera and the O-20 SHORAN Recording Camera, which results in an error between the apparent ground position and the SHORAN ground position. The SHORAN Recording Camera is triggered from the shutter of the T-11 Vertical Camera, and any error occurring will equal the lag in synchronization times the ground speed. (This lag averaged 17.8 milliseconds, which amounted

to approximately 10-20 feet at speeds flown during this test.)

3. Errors contained within the SHORAN system itself were evaluated.

4. Overall accuracy in a tactical situation would be affected by the following errors: Calibration of the SHORAN ground stations, calibration of the AN/APN-84 SHORAN Radio Set, and errors of camera calibration. In addition, compass error will affect the correct location of any offset targets contained within the Vertical Camera photo. True North orientation must be accomplished prior to locating targets in positions other than the center of the photograph.

(c) One hundred and twelve frames of film were gathered from the 14 missions flown at 20,000 feet altitude. Of these 112 frames, 83 were usable for data evaluation. Twenty-nine frames were not evaluated because of "Apparent Gross Error" (over 1000 feet) contained in either the Principal Point or SHORAN position, when compared with the Nadir position. Analysis of test results indicates that the major portion of the "gross errors" occurred during the initial missions flown during the test and were primarily attributed to operator error. As additional familiarization with the system was obtained by the operator, accuracy of results improved considerably, indicating that proficiency in operation will influence greatly the results obtained with this reconnaissance system.

Deflection Errors

(Errors to the right or left of the aircraft's flight path)

$\sigma Z =$ Standard deviation of deflection errors

Range Errors

(Errors over or short measured along the aircraft's flight path)

$\sigma X =$ Standard deviation of range errors

20,000-Foot Altitude

$\sigma Z_1 = 184$ Feet (SHORAN Error)

$\sigma Z_2 = 327$ Feet (Principal Point Error)

Combined Deflection Error $\sigma Z_3 = \sqrt{\sigma Z_1^2 + \sigma Z_2^2}$

Deflection Error $\sigma Z_3 = 375$ Feet

$\sigma X_1 = 123$ Feet (SHORAN Error)

$\sigma X_2 = 264$ Feet (Principal Point Error)

Combined Range Error $\sigma X_3 = \sqrt{\sigma X_1^2 + \sigma X_2^2}$

Range Error $\sigma X_3 = 291$ Feet

CEP (Circular Probable Error) $\approx .5887\ (\sigma X_3 + \sigma Z_3)$

CEP $\approx$ 392 Feet

40,000-Foot Altitude

$\sigma Z_1 = 1351$ (SHORAN Error)

$\sigma Z_2 = 841$ (Principal Point Error)

Combined Deflection Error $\sigma Z_3 = \sqrt{\sigma Z_1^2 + \sigma Z_2^2}$

Deflection Error $\sigma Z_3 = 1591$ Feet

$\sigma X_1 = 1741$ (SHORAN Error)

$\sigma X_2 = 443$ (Principal Point Error)

Combined Range Error $\sigma X_3 = \sqrt{\sigma X_1^2 + \sigma X_2^2}$

Range Error $\sigma X_3 = 1796$ Feet

CEP $\approx .5887\ (\sigma X_3 + \sigma Z_3)$

CEP $\approx$ 1994 Feet

(d) Statistical analysis revealed no significant bias in range or in deflection for either the SHORAN or Principal Point distribution of errors (i.e., no systematic error present in the SHORAN or camera system.)

(e) Analyzing the resultant CEP derived from the data gathered at 20,000 feet altitude and comparing this value with a basic bombing CEP (600 feet) will indicate the overall accuracy to be expected when performing SHORAN Reconnaissance missions at 20,000 feet altitude with the MA-3 system. (Reference the final report on Operational Suitability Test on the S-4 SHORAN Bombing System, Project No. APG/SAS/71-A-1, Appendix L, Increase in CEP due to Inaccurate Geodetic Data.) The CEP of the MA-3 SHORAN Reconnaissance System when flown at 20,000 feet was 392 feet. The following formula was used against a bombing CEP of 600 feet to evaluate the effect of the MA-3 system error on a bombing CEP.

$(CEP)_r$ = Resultant CEP

$(CEP)_b$ = Basic Bombing CEP (600 feet)

E_t = Total error of MA-3 system (392 feet)

$$(CEP)_r = \sqrt{(CEP)_b^2 + E_t^2}$$

$$(CEP)_r = 717 \text{ feet}$$

It can be expected that the error of 392 feet as contained in the MA-3 system will not increase a 600-foot bombing CEP by more than 117 feet.

(f) Only 17 frames were obtained from the 3 missions flown at 40,000 feet altitude, of which 13 frames were used in evaluation. (Four errors ranging from 9,000 to 17,000 feet were rejected.) Comparison of this data against that gathered at the 20,000-foot altitude does not provide a conclusive indication of the potential capability of this system at this altitude. It may be noted, however, that a proportional increase in CEP can be expected as altitude is increased due to stabilization errors of the terrain camera.

but that SHORAN errors will remain substantially the same. Because over 50 percent of the frames gathered contained gross errors (over 1,000 feet), these results indicate that excessive difficulties will be encountered both in operation and in maintenance when performing reconnaissance with this system, as installed, at altitudes of 40,000 feet or above. (Reference paragraph 5d(1)(d).)

b. Operational Capabilities and Limitations:

(1) Procedures:

(a) At least three minutes prior to entering the target area (reference Appendix B, Operating Procedures for the MA-3 System, Pretarget Procedure), the Automatic S_1 and S_2 Synchronizing Motor Switches were turned on to insure proper synchronization. Upon completion of the target run, these switches and the A-28 gyro-stabilized mount control switch were turned off to prevent loss of SHORAN pulses and tumbling of the gyro in the A-28 mount should the aircraft be required to perform abrupt maneuvers.

(b) Prior to the development of the MA-3 SHORAN Reconnaissance Navigational System, transmissions from aircraft to ground SHORAN stations consisted of a singular pulse. The MA-3 system utilizes a double pulse transmitting arrangement incorporating a code delay system which provides a selection of three separate delays (3, 4.5, and 6 microseconds) between each set of transmitted pulses. Changing the delay between transmitted pulses provides the capability of eliminating interference from SHORAN transmissions of other aircraft which are utilizing the same ground stations.

(2) Test Results and Analysis:

(a) Two strobe lamps are presently used to illuminate the dials of the C-1689 Indicator Unit. One lamp illuminates the altimeter, free air temperature, and compass heading indicators and the other lamp illuminates the rate and drift station distances to the aircraft. (Reference Figure 4.) Intermittent failure of these lamps occurred on several of the test missions, causing blanking on the O-20 film. (Reference Figure 5.) It was determined that this failure was caused by an intermittent malfunction of the bulb itself, rather than a failure within the system. Should this failure occur over the target area, the mission would be ineffective.

(b) The MA-3 SHORAN Reconnaissance Navigational System is capable of performing reconnaissance against targets at line-of-sight distances from the SHORAN stations, when flown at altitudes at least up to 20,000 feet. (Twenty thousand feet of altitude will give a resultant line-of-sight distance of approximately 195 statute miles, and 40,000 feet of altitude will give a resultant line-of-sight distance of 275 statute miles.)

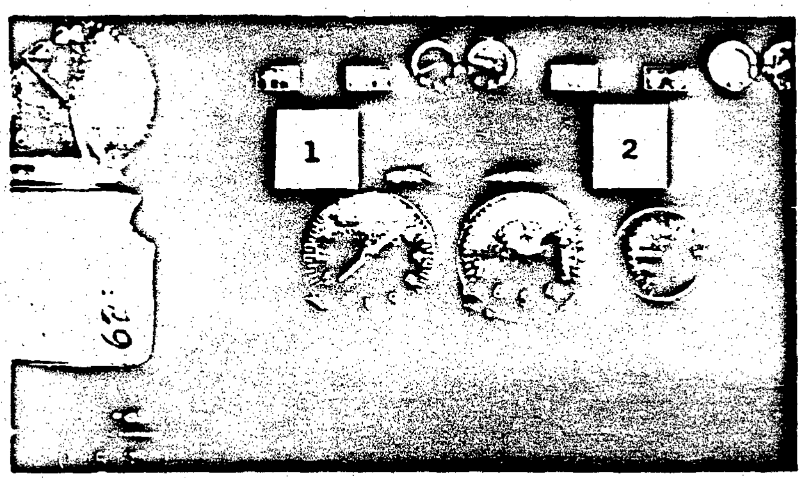

Figure 4

35mm Film of O-20 Camera in the Recorder Showing Proper Operation of Strobe Lights, Illuminating Both Rows of Dials, and Showing How Dials Can Be Misread.
Reading on Dial No. 1 - 119.868 (Could Be Misread as 119.968).
Reading on Dial No. 2 - 109.286 (Could Be Misread as 109.386).

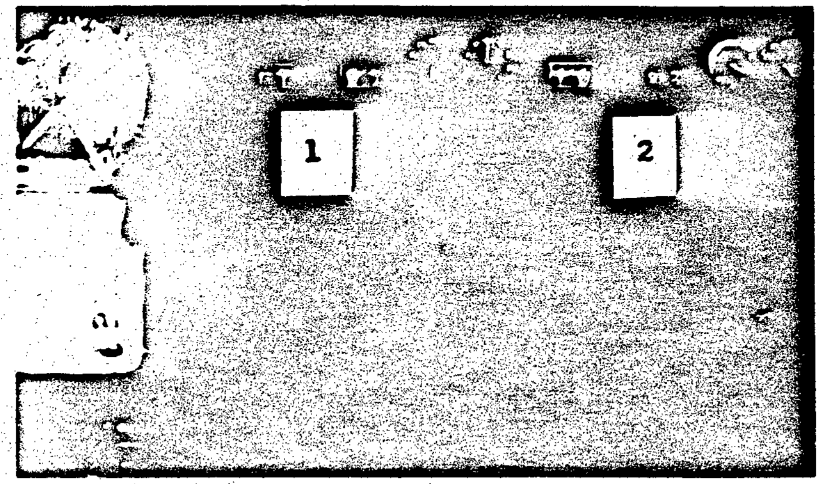

Figure 5

35mm Film of O-20 Camera in the Recorder
Showing Failure of Lower Strobe Light.
Reading on Dial No. 1 - 119.450
Reading on Dial No. 2 - 109.334

(c) If the aircraft exceeds approximately 20 degrees on any turn or bank, excessive precession of the A-28 mount gyro and loss of received SHORAN pulses will occur.

(d) On all missions flown, absolute altitude was measured and incorporated into the MA-3 system once the briefed altitude had been reached. (Reference Appendix B, Operating Procedures for the MA-3 System, Altitude Measurement.) Remeasurement of altitude proved extremely difficult once the vernier counters were disengaged. In accordance with the operating procedures for the MA-3 system, the vernier counters on the AN/APN-84 were disengaged upon completion of the first altitude measurement. Should these counters be left engaged, they would be forced to drive at speeds that would exceed their capabilities (300 knots) while connected to the counters in the Recorder Group. (With the vernier counters disengaged, there is no external way of reading the values appearing in the recorder.) The procedure used for re-engaging the counters was for the operator to remove his shoulder harness, safety belt, and helmet and view the counters through the O-20 Camera port. (Reference Figure 1.) At this time, values for the new altitude were incorporated into the MA-3 system.

c. Procedures for Running a Flight Line with the MA-3 SHORAN Reconnaissance System:

(1) Test Environment and Procedures:

(a) All missions were accomplished either by positioning and maintaining the aircraft on the SHORAN arc, or by having the pilot line up visually on the proposed flight line. (The proposed flight line consisted of Northeast and Southwest headings over the photogrammetric range, which is approximately 7 miles in length.) While flying the flight line visually, the cameras were turned on by the operator when the aircraft was properly positioned over the target by the pilot. This method proved to be satisfactory for altitudes up to 20,000 feet. Above this altitude it became difficult for the pilot to fly directly over the proposed flight line because his forward vision of the ground was impaired in the RB-57 type aircraft as altitude was increased. Flying the flight line visually allows an infinite number of approaches to the target.

(b) The second method used was to fly a SHORAN arc passing through the target. The operator maintained SHORAN fixes with the aid of Range Indicator ID-509(XA)/APN-84 (Rate and Drift Indicator), which shows the SHORAN mileage from both the rate and drift stations. (Reference Figure 3.) For an operational tactical situation, approximate (within 5 miles) SHORAN coordinates of the target should be available to reconnaissance crews prior to performing a mission with the MA-3 system. With the pilot following the numerical indications of the Rate and Drift Indicator (which replaces the former Position Deviation Indicator), minimum voice communications were required from the operator to the pilot to direct the aircraft to the drift arc. A point approximately 20 miles short of the desired flight line was selected to intercept the arc. Interception of this arc was made at an angle of 30-60 degrees. Once the aircraft was on the correct drift arc, the pilot followed the reading on his Rate and Drift Indicator and, during the remainder of the target run, no further voice directions were required from the operator. By flying the SHORAN arc, four approaches were possible.

(c) To obtain optimum utilization of the photogrammetric range, the ID-510(XA)/APN-84 Sum Indicator and the ID-511(XA)/APN-84 One-Half Difference Indicator were not used. (By maintaining a constant value on the sum meter, an elliptical pattern around both ground stations may be flown. By maintaining a constant value on the One-Half Difference Indicator, a hyperbolic pattern may be flown around either ground station, or a straight line may be flown midway between the two ground stations.)

(d) Missions flown during this test utilized both automatic and manual tracking runs. In the event of automatic tracking failure, the manual controls may be used. During the conduct of this test, automatic tracking failure did not occur, but several runs were accomplished utilizing manual operation. This operation is similar to the SHORAN bombing operation, where the operator keeps the received pulses aligned with the marker pulses. This requires the SHORAN operator to use both hands when tracking pulses, and leaves him little time to operate and monitor camera and MA-3 controls.

(e) A total of five missions were flown incorporating "noise" (simulating other aircraft utilizing the same ground stations). Flight lines were made with the test aircraft with a variance of from 5 to 19 simulated aircraft.

(f) The aircraft was navigated to the target area with the aid of SHORAN fixes obtained from the operator's Rate and Drift Indicator, ID-509(XA)/APN-84. Prior to entering the target area, the camera equipment was given the pre-target check in accordance with the operator's check list. The pilot then flew the aircraft over the flight line either visually or by the Rate and Drift Indicator, as briefed by the SHORAN operator. During the camera run the SHORAN operator was required only to monitor pulses and "ride" the gain controls.

(2) Test Results and Analysis:

(a) The automatic tracking feature of the MA-3 system provides the operator with greater ease of operation and leaves his hands free for monitoring other equipment, which is conducive to greater accuracy during the target run. Indicating a constant value on either the Sum or One-Half Difference Indicators provides a capability of utilizing SHORAN operation by flying four additional approaches to the target other than the conventional four-arc approach.

(b) During the missions incorporating "noise," the operator found it difficult to differentiate between actual and simulated pulses displayed on the SHORAN indicator. Since manual operation requires the operator to align received pulses visually with their corresponding reference pulses, any interference mixed with received pulses causes difficult scope interpretation. When the MA-3 system is operating in the automatic position, pulses are aligned electronically, and chances of operator errors are lessened considerably. With the test aircraft and 19 simulated aircraft, no detrimental effect on MA-3 operation was encountered when the system was operating in the automatic position.

(3) Tactics and Techniques:

(a) Upon completion of the prescribed preflight (reference Appendix B), the MA-3 system was left in the OPERATE position during start, taxi, and takeoff. The main camera control panel was not pivoted into its usual operating position because it interfered with the operator's reaching the MA-3 controls and partially blocked the view of the indicator scope. The procedure in the test aircraft was to preset all camera switches and dials prior to takeoff, leaving the control panel latched to the right bulkhead while airborne. In the test aircraft, the cameras were operated with the master control box located on the operator's left console. (Reference Figure 1.) This arrangement proved to be the most satisfactory.

(b) An excessive bank (approximately 20 degrees in the test aircraft) tends to blank out SHORAN signals, resulting in a loss of pulses and tracking by the MA-3 system. Abrupt or violent maneuvers cause the tracking system to lose and hunt the SHORAN pulses, resulting in erroneous SHORAN dial readings. It is essential that the pilot hold the aircraft straight and level during the target run so that the data gathered may be as accurate as possible.

d. Reliability of Equipment and Maintenance Requirements:

(1) Test Results:

(a) Three of the 20 test missions evaluated were considered to be air aborts because the MA-3 system or its allied equipment malfunctioned while airborne. It may be noted that two of these aborts were during high altitude missions. (Reference paragraph (d) following.)

(b) Total direct organizational maintenance including preflight, postflight, and periodic inspections amounted to 258 maintenance man-hours for 43 flying hours. This gives a resultant 6:1 maintenance-to-utilization ratio, but is not indicative of the test item because of the inadequacy of existing maintenance publications pertaining to the MA-3 system. One hundred and fifty-two of the 258 maintenance man-hours expended were attributed to "trial-and-error" maintenance prior to a local "fix" performed on the AN/APN-84 T-342 Transmitter. (Reference paragraph (c) following.) Deleting the 152 hours from the total of 258 gives a resulting maintenance-to-utilization ratio of 2.46:1. This ratio compares almost identically with the 2.48:1 maintenance-to-utilization ratio of the S-4 SHORAN Bombing System. (Reference Air Proving Ground Command final report on the Operational Suitability Test of the S-4 SHORAN Bombing System, Project No. APG/SAS/71-A-1.)

(c) A repeated malfunction in the MA-3 system was the frequent cut-off of the AN/APN-84 T-342 Transmitter. The double trigger in the MA-3 system causes too heavy a load on the oscillator tubes and, consequently, the overload relay will cut off the transmitter. In order that testing could continue without an excessive delay, an emergency "fix" was made by the addition of a 15,000-ohm resistor, type R-151, in parallel with the present 15,000-ohm resistor and the overload relay, type K-107, in the T-342 Transmitter Oscillator. To eliminate any possibility of burning out components of the T-342 Transmitter Oscillator, the associated high voltage power supply was modified to produce a lower output voltage. This modification is not recommended, since it decreases the maximum usable SHORAN range. The system then operated satisfactorily, but it is recommended that the power supply and transmitter oscillator be redesigned to be compatible with the Recorder Group.

(d) It was also found that the mechanical commutator in the T-342 Transmitter Oscillator malfunctioned during and after missions at 40,000 feet. This malfunction was caused by cam wear and excessive relay arcing at high altitudes (reference Air Proving Ground Command final report on the Operational Suitability Test of the S-4 SHORAN Bombing System, Project No. APG/SAS/71-A-1), resulting in a high malfunction rate. It is also noteworthy that this same malfunction was observed and reported in the final report on the Operational Suitability Test of the B-57B Aircraft, Project No. APG/TAS/119-A. Replacement of the mechanical commutator with an electronic switching device should eliminate this malfunction.

(e) During the conduct of the test, the average preflight time was 1.5 man-hours based on a total of 26 inspections. A 30-minute operational check will suffice in preparation for an immediate flight; however, the AN/APN-84 should be operated longer to dry out any transmitter moisture. This prevents erratic operation of the transmitter.

e. <u>Preflight Requirements and Computations Necessary for Proper MA-3 SHORAN Operation:</u>

(1) <u>Test Environment and Procedures:</u>

(a) Preflight warm-up time was 40 minutes as recommended in the Air Proving Ground Command final report on the Operational Suitability Test of the S-4 SHORAN Bombing System, Project No. APG/SAS/71-A-1. Preflight was accomplished using the check list developed during the conduct of this test. (Reference Appendix B.)

(b) No preflight or inflight computations are required for insertion into the MA-3 system, since preflight procedures call for zeroing all counters and syncros.

(2) <u>Tactics and Techniques:</u> All preset data necessary for the mission were incorporated into the system during the 40-minute warm-up period. It is desirable that the preflight be accomplished with the auxiliary power supply plugged into the aircraft, and that the

system be left in the TEST or OPERATE position during aircraft start and takeoff. This enables the aircraft to proceed to the target area without an additional requirement for warm-up, once airborne.

f. AFSC's and Training Required for Personnel to Operate and Maintain the MA-3 System:

(1) Test Environment and Procedures:

(a) SHORAN Airborne Operators: Three operators participated in the test missions flown on this project. One had no previous SHORAN experience other than a two-week indoctrination course given by the Air Training Command in the past B-26 Observer Training Program. The other two operators were fully qualified in AN/APN-3 SHORAN Bombing operation, both having completed a tour utilizing SHORAN operation in the recent Korean conflict.

(b) Pilots: Of the four pilots participating in test missions, only one had previous experience with SHORAN operation and flight techniques.

(c) Maintenance: Two airmen (AFSC 30151 AB) were assigned to maintain the AN/APN-84 Radio Set portion of the MA-3 system equipment. They were directed and assisted by the AFAC project engineer in all problems relative to operation and maintenance of the Recorder Group.

(2) Test Results and Analysis:

(a) Personnel and Training: The average airman with a 30151 AFSC can perform organizational and field maintenance on the MA-3 system provided qualified personnel are available to conduct on-the-job training (OJT). The operation and maintenance procedures for the MA-3 system should be integrated into the AN/APN-84 curriculum. This course is presently conducted at Keesler Air Force Base, Mississippi, as AB30131B, "Airborne Electronic Navigation Equipment Repairman (SHORAN)."

(b) SHORAN Operators: Operators with previous SHORAN experience should have no trouble becoming proficient in MA-3 operation upon completion of proper orientation. Fifteen hours of lecture is deemed necessary for operator orientation concerning the theory and operation of this system, and five hours of practice preflight operations on a bench mock-up and ground aircraft operation are considered necessary. Inflight training is recommended in some training aircraft such as the C-47 in order that the student operator may be accompanied by an instructor. During the inflight instruction, at least 15 photo runs should be accomplished. This training could be conducted at squadron or wing level.

(c) Observers (AFSC 1525, 1534, and 1554): Observers who are not experienced SHORAN operators should complete an indoctrination course of approximately three weeks' duration on MA-3 theory and operation.

(d) Pilots: In addition to being fully qualified in the RB-57 type aircraft, a pilot should receive approximately four hours of ground school instruction and fly at least 15 practice photo runs to become familiar with the system. Pilots with previous SHORAN experience had no difficulty utilizing the Rate and Drift Indicator.

g. Adequacy of Existing Operating and Maintenance Publications and Ground Support Equipment:

(1) Test Results:

(a) Technical Publications: Presently there is no standard Handbook of Operating Instructions, Handbook of Maintenance Instructions, or Parts Catalog available for the MA-3 system. Unless these publications are provided, excessive maintenance efforts will be needlessly expended.

(b) Ground Support Equipment: There are no additional requirements for ground support equipment, other than normal auxiliary power used during RB-57A aircraft preflight and starting.

(c) Supply: There is no standard list of spare parts for the MA-3 system and components; however, Technical Order 11B32-2-3-4, dated 1 September 1955, provides a spare parts list for the AN/APN-84 SHORAN Radio Set. Any other parts must be packaged and returned to the factory to obtain replacement items. The packaging of incoming items was adequate throughout the test.

5. SUMMARY:

a. In its present configuration, the MA-3 SHORAN Reconnaissance Navigational System has an altitude limitation which is considerably below that of the capability of the RB-57A aircraft. When operating the MA-3 system at or above approximately 40,000 feet altitude, malfunction of the T-342 Transmitter Oscillator renders the system inoperative. Operational missions will have a poor reliability rate, unacceptable SHORAN Reconnaissance accuracy, and an excessively high maintenance-to-utilization ratio when the system is employed at these altitudes.

(1) Further testing of this equipment with this deficiency uncorrected would parallel results of previous tests in which the same malfunction and corresponding recommendations were reported. Until such time that modifications as recommended in this report are incorporated into the AN/APN-84 portion of the MA-3 system, the MA-3 system will be operationally unsuitable for performing SHORAN Reconnaissance at the optimum altitudes of the RB-57A aircraft.

(2) Since previous recommendations (reference Air Proving Ground Command final reports on the Operational Suitability Test of the SHORAN Bombing System, Project No. APG/SAS/71-A-1, and Operational Suitability Test of the B-57B Aircraft, Project No. APG/TAS/119-A) to have the AN/APN-84 T-342 Transmitter installed in a pressurized compartment

of the aircraft have not been accomplished, redesign of the T-342 Transmitter Oscillator is strongly recommended.

b. In addition to providing target coordinates for SHORAN bombing, the MA-3 system has the potential capability of providing target data required for AN/MSQ-1 and missile guidance in areas where geodetic data are unreliable; however, a somewhat lesser degree of accuracy in target location is expected since a change in coordinate systems is involved.

RECOMMENDED MODIFICATIONS FOR THE MA-3 SYSTEM TO ELIMINATE MINOR DEFICIENCIES ENCOUNTERED DURING THE CONDUCT OF THIS TEST

1. During the conduct of this joint functional-operational evaluation, minor deficiencies were discovered in the MA-3 system. Recommended modifications are:

a. Incorporate an automatic altitude measuring system into the MA-3 system to permit utilization of continuous and accurate altitude information for improved accuracy.

b. Locate the pilot's SHORAN flight indicators on the main console so they are in his direct line-of-vision, readily visible at a glance.

c. Install a double set of strobe lights for each set of dials in the Recorder Group, to insure proper functioning should one fail. (Reference paragraph 5b(2)(a).)

d. Replace the present Veeder Root Counters with gas meter type dials to avoid misreading. (Reference Figures 4 and 5.)

e. Locate the control switch for the A-28 Gyro-Stabilized Camera Mount with the other controls of the MA-3 system for ease of operation. (In the test aircraft, the A-28 mount control switch was located inconveniently to the right of the operator, requiring him to alternate positions when operating this control.)

OPERATING PROCEDURES FOR THE MA-3 SYSTEM

FUNCTION	POSITION
GROUND PREFLIGHT	
Turn On	
IP-186	
1. Standby switch	Test
2. Power switch on	Depress; standby light should light
3. Interchange switch	Rate low frequency
4. Scale miles switch	1 mile
5. Observe trace on scope	Adjust brightness and focus
C-1698	
6. Syncro switch on recorder	Off
7. Power switch on recorder	On (observe three red lights on)
8. O-20 Camera	Removed
ALIGNMENT	
IP-186 and C-1698	
1. Counter release	Engage
2. Vernier (rate and drift)	Set to 0.000
3. Counter release	Release
4. Reference dials (rate and drift)	Set to nearest zero
5. Rate reference button	Depress and hold

6.	Displacement knob on C-1698	Rotate until rate reference button detents
7.	Rate counter release	Engage
8.	Repeat steps 5, 6, and 7 to align drift channel.	
9.	Check to see if all counters read zero (check IP-186 and C-1698). If all counters do not read zero, follow steps 10-12.	
10.	To reset counters, disengage gear box coupling.	
11.	Drive S_1 and S_2 motors to zero counter in C-1698 with switches in manual.	
12.	When all counters read zero, engage gear box coupling (check to see that all counters still read zero after coupling).	

ZERO CHECK

(Allow 40 minutes warm-up prior to Zero Check.)

<u>IP-186</u>

1.	Rate and drift vernier	Set to 9.834
2.	Standby switch	Operate
3.	Brightness and focus	Adjust
4.	Zero check switch	Up (red light on)
5.	Tune low frequency	
6.	Gain No. 1	Set for proper gain

7.	Zero set	Align low frequency marker pulse
8.	Code select on CM-75	Desired code delay
9.	Standby switch	Auto-Operate
	<u>C-1698</u>	
10.	Rate syncro switch. Check vernier counter for slewing away from base station reference mileage (9.834).	Auto
11.	Rate syncro switch	Off
12.	Standby switch	Operate
13.	Tune high frequency	
14.	Gain No. 2	Set for proper gain
15.	Zero set	Align high frequency marker pulse
16.	Code selector C-1698	Desired code delay
17.	Standby switch on IP-186	Auto-Operate
	<u>C-1698</u>	
18.	Drift syncro switch. Check for slewing away from 9.834.	Auto
19.	Syncro switch	Off
	<u>IP-186</u>	
20.	Standby switch	Calibrate
21.	Zero check switch	Down (red light out)

C-1698

22.	Internal light switch	Off
23.	Install 0-20 Camera on C-1698	
24.	Record zero switch	Depress 50 times to take up leader on film.

INFLIGHT

During climb to altitude make following zero check:

1.	Rate vernier	Set to 9.834
2.	Drift vernier	Set to 0.000
3.	Repeat steps 2 through 10 of ground zero check procedure	
4.	Record zero switch	Depress 3 times
5.	Standby switch	Operate
6.	Rate syncro switch	Off
7.	Rate vernier	Set to 0.000
8.	Drift vernier	Set to 9.834
9.	Repeat steps 13 through 18 of ground zero check procedure	
10.	Record zero switch	Depress 3 times
11.	Drift syncro switch	Off
12.	Standby switch	Operate
13.	Zero check switch	Down (red light out)

UPON REACHING BRIEFED ALTITUDE, MEASURE ALTITUDE. AFTER REACHING TRUE BOMBING ALTITUDE, DISENGAGE BOTH RELEASE COUNTERS (COUNTERCLOCKWISE).

[redacted]

ALTITUDE MEASUREMENT PROCEDURE

1. Fly aircraft over water or over level terrain of known elevation.

2. When aircraft is near bombing altitude, notify pilot that altitude is to be measured and that aircraft should be flown level.

3. Pre-set bombing altitude in miles in the rate vernier window.

4. Tune SHORAN receiver to either high or low transmission frequency, preferably the rate station frequency. A weak but usable rate pulse reflected from the ground will appear. Standby switch should be in the OPERATE position.

5. Have the pilot climb or descend to align reflected rate pulse and marker pulse.

6. When pulses are aligned, have pilot record and fly the altitude indicated on his pressure altimeter.

ALTITUDE IN FEET EQUALS (=) MEASURED ALTITUDE TIMES (X) 5280 PLUS (+) 877 FEET.

20,000 Feet	3.62178
25,000 Feet	4.56875
30,000 Feet	5.51572
35,000 Feet	6.46269
40,000 Feet	7.40966

CALIBRATION

1.	Counter release	Release
2.	Call ground stations and request a calibration pulse	
3.	Tune for ground stations	
4.	Scale miles	100 miles

[redacted]

[redacted]

5. Cal. adjust — Stop rotating pulse on 100-mile, 10-mile, and 1-mile scales.

6. Call ground stations and request they turn to operate.

TUNING

1. Standby switch — Operate

2. Scale miles — 100 miles

3. Tune ground stations — Tune to midpoint between stations

4. Gain No. 1 and No. 2 — Adjust for proper gain

5. Recheck that vernier counters are disengaged.

6. Recheck that zero check switch is down (red light out).

7. Recheck that internal lights in C-1698 are off.

PRETARGET

1. Standby switch — Auto-Operate

2. Scale miles — 100

3. Rate and drift syncro switches — Auto

4. When pulses are within 1 mile of marker pulse, switch to 1-mile scale.

5. Continue to monitor gain riding.

AT TARGET AREA

1. Operator need only to ride gain and operate cameras.

[redacted]

POST TARGET AREA

1. Repeat inflight zero check and record zero procedure.
2. Allow aerial camera to run to take up trailer (about 10 pictures).
3. Shut off cameras.
4. Record zero 50 times to leave trailer in camera.

TURN OFF

1.	Standby switch	Test or calibrate
2.	Recorder power switch	Off
3.	SHORAN power switch	Off

S.O.P. FOR A-28 MOUNT FOR AERIAL CAMERA

1. Do not turn on until altitude is reached and aircraft is in level flight. After turn-on, allow 3 minutes to warm up and settle out.
2. Turn off before going into a turn.
3. Turn camera compartment temperature control to ON.

DAY ALTITUDE PHOTOGRAPHY

1. Turn all camera switches OFF.
2. Turn camera main power switch to ON.
3. Turn camera compartment temperature control to ON.
4. Set up camera controls as required.

ENTERING TARGET AREA

1. Turn master control panel power switch to ON.

[redacted]

2. Turn master control panel ready switch to ON. This switch opens the camera doors. Wait approximately 1 minute or until green light is on, indicating camera doors are open. If green light does not come on, a malfunction may have occurred.

AT TARGET

1. Turn master control panel operate switch to ON.

POST TARGET

1. Turn operate switch to OFF.

2. At end of mission turn off all switches.

END OF REPORT

[redacted]

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE MATERIEL COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

MAY 23 2000

MEMORANDUM FOR DTIC/OCQ (ZENA ROGERS)
8725 JOHN J. KINGMAN ROAD, SUITE 0944
FORT BELVOIR VA 22060-6218

FROM: HQ AFMC/SCDP
4225 Logistics Avenue, Room A112
Wright-Patterson AFB OH 45433-5744

SUBJECT: Change in Distribution Statement for AFMC Documents

1. Distribution statements on several documents were officially changed to Distribution Statement A in accordance with AFI 61-204, 27 Jul 94, *Disseminating Scientific and Technical Information*. The documents (excluding those marked out in Atch 3) are owned by AFMC and were reviewed by the HQ AFMC History Office and HQ AFMC Public Affairs Office. The documents cleared for public release are listed on three attachments.

2. Please direct further questions to Ms. Lezora Nobles, AFMC STINFO Assistant, HQ AFMC/SCDP, DSN 787-8583.

Patricia T. McWilliams

PATRICIA T. McWILLIAMS
AFMC STINFO Program Manager
Directorate of Communications and Information

Attachments:
1. AFDTC/PA Memo, 11 Jan 95
2. HQ AFMC/PAX 1st Ind, 4 May 00
3. HQ AFMC/PAX Memo, 5 May 00

2. Attachments a through c are part of an internal AFMC/HO review; attachments d and e are requested by Mr. Morris Betry, a private researcher; attachments f through h are requested by Ms. Pat McWilliams (AFMC/SCDP); and attachment i is requested by Mr. Gregory Hughes (ASC/ENFD).

3. The AFMC/HO point of contact for these reviews is Dr. William Elliott, who may be reached at extension 77476.

JOHN D. WEBER
Command Historian

~~8~~ 6 Attachments:
a. ~~AFSC No. 150.174~~
b. ~~AFSC No. 400.490~~
c. DTIC No. AD-098 048
d. DTIC No. AD-376 934
e. DTIC No. AD-895 879
f. DTIC No. AD-094 838
g. DTIC No. AD-068 388
h. DTIC No. AD-046 931
~~i. AFLC No. R1-120-2~~

1st Ind, HQ AFMC/PAX 4 May 2000

This material has been reviewed for security and policy IAW AFI 35-101. It is cleared for public release.

JAMES A. MORROW
Security and Policy Review
Office of Public Affairs

atch 2